APPLICATION

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TITLE: FASTENER PRODUCTS WITH MULTIPLE ENGAGEMENT ANGLES

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FASTENER PRODUCT WITH MULTIPLE ENGAGEMENT ANGLES

TECHNICAL FIELD

This invention relates to fastener products and more particularly to fastener products having multiple engagement angles.

BACKGROUND

This invention relates generally to touch fasteners, and specifically to touch fasteners for engaging fibers and to methods and apparatus for their manufacture.

There has been much development over the last thirty years in the field of hook-and-loop fasteners. Early touch fastener products of this type consisted of two mating tapes, each being knit or woven. One tape would include loops of filament woven into a base, and the other would include filaments woven to form loops and then cut to form hooks. In some cases free ends of drawn plastic filaments on the male tape would be melted to form protruding heads. This shape of fastener element is sometimes called a "mushroom", to distinguish it from "hook"-shaped elements with re-entrant crooks.

More recently, continuous molding of fastener elements extending from a common sheet-form resin base has resulted in less expensive and thinner male tapes. Significant improvements in this area include the development of continuous fastener tape molding using fixed mold cavities (see Fischer, U.S. Patent 4,794,028), and the ability to provide loops on the back side of the male fastener tape as the fastener tape substrate and elements are being formed (see Kennedy et al., U.S. Patent 5,260,015), thus creating a composite fastener tape capable of fastening to itself.

Much recent development has been directed at making fastener products having fastener elements that extend in a common orientation. As discussed below, there is a need or desire for a releasable fastener having multiple angles of engagement.

SUMMARY

In various aspects, the present invention features fastener products having individual fastener elements with stems integrally molded with a base and extending in different directions.

In one aspect, the invention features a method of forming a fastener product and includes providing a continuous, sheet-form base having an array of fastener elements including molded stems extending outwardly from the continuous, sheet-form base and splitting the base between adjacent rows of the molded fastener elements to form elongated fastener filaments and twisting the fastener filaments individually to reorient the fastener elements to extend in multiple directions from a common core.

Implementations may include one or more of the following features. The method includes splitting the base longitudinally along the continuous, sheet-form base. The base is split so that the fastener filaments each have only one row of fastener elements.

In some embodiments, the method includes winding at least two of the twisted fastener filaments together to form a yarn having fastener elements extending outwardly in multiple directions.

In some cases, the method includes depositing twisted fastener filaments on a substrate to form a field of exposed fastener elements extending from the substrate. Where the twisted fastener filaments are deposited on the substrate, the twisted fastener filaments are deposited on the substrate in a predetermined pattern. In these embodiments, the predetermined pattern can approximate a line extending substantially parallel to a longitudinal edge of the substrate. The predetermined pattern can also be wave-like. In other embodiments, the twisted fastener filaments are deposited randomly on the substrate.

In some embodiments, the method includes weaving the twisted fastener filaments to form a woven material. The twisted fastener filaments can be woven with a non-fastener filament to form the woven material.

In some cases, twisting the fastener filaments individually to reorient the molded fastener elements to extend in multiple directions from a common core further includes heating the fastener filaments.

Some embodiments include prior to providing the substrate, molding the continuous, sheet-form base having stems of fastener elements, the stems integrally molded with and extending from the substrate.

In some cases, the method includes cooling the twisted fastener filament.

In another aspect, the invention features a method of forming a fastener product and includes molding rows of fastener elements formed of synthetic resin on a mold roll, the mold

roll has a plurality of fastener element cavities and the fastener elements include stems extending outwardly from and integral with a continuous, sheet-form base; and splitting the continuous base between individual rows of molded fastener elements to form elongated fastener filaments, each fastener filament having one row of fastener elements.

Implementations of may include one or more of the following features. For example, the method includes splitting the continuous sheet of material in the machine direction.

In some cases, the method includes chopping the fastener filaments into a plurality of filament pieces. This can further include applying the filament pieces to a material.

In some embodiments, the method further includes winding at least two fastener filaments to form a yarn having fastener elements extending in multiple directions.

In yet another aspect, the invention features a method of forming fastener filament material and includes molding a continuous, sheet-form base having rows of fastener elements formed of synthetic resin, the fastener elements having stems that extend outwardly from and integral with the continuous, sheet-form base; splitting the continuous base between adjacent rows of the molded fastener elements to form elongated fastener filaments; cutting the fastener filaments into discrete lengths of fastener filament strands; and depositing the fastener filament strands on a substrate to form a field of exposed fastener elements extending from the substrate.

Implementations may include one or more of the following features. For example, the method includes twisting the fastener filaments to reorient the molded fastener elements to extend in multiple directions from a common core.

In some cases, the method includes attaching the deposited fastener filament strands to the substrate. The fastener filaments can be attached to the substrate by engagement of the fastener elements with fibers. Also, the fastener filaments can be attached to the substrate by bonding the fastener filaments to a surface of the substrate.

In some embodiments, the substrate has a plurality of fibers sized to engage the fastener elements.

Some embodiments include the substrate having non-woven fibers.

In some cases, the fastener elements are sized to engage one of loops of a loop material and the substrate to a greater extent and the other to a lesser extent.

In some embodiments, the fastener filament strands are deposited randomly on the substrate. Alternatively, in other embodiments, the fastener filament strands are deposited on the substrate in a predetermined pattern.

In another aspect, the invention features a method of forming a nonwoven web comprising fastener filament material and includes molding a continuous, sheet-form material having rows of fastener elements formed of synthetic resin, the fastener elements having stems that extend outwardly from and integral with the continuous, sheet-form material; splitting the continuous sheet of material between adjacent rows of the molded fastener elements to form elongated fastener filaments; twisting the fastener filaments individually to reorient the molded fastener filaments to extend in multiple directions from a common core; cutting the fastener filaments into discrete lengths of fastener filament strands and forming a nonwoven web material comprising the discrete lengths of fastener filament strands.

Implementations may include one or more of the following features. For example, the method of forming a nonwoven web is selected from the group consisting of airlaying, carding and wetlaying. The group can include thermoplastic staple fibers and/or cellulosic fibers.

In some cases, the method includes bonding the nonwoven web material. Bonding can include a bonding process selected from the group consisting of entanglement bonding, through-air bonding, thermal point bonding, ultrasonic bonding and adhesive bonding. The bonded material can be used to form a protective garment.

In some embodiments, the nonwoven web material forms a laminate material.

In some cases, the nonwoven material forms a personal care product.

The nonwoven web of some embodiments forms a protective garment.

In yet another aspect, the invention features a method of forming a fastener product including providing a sheet-form material having rows of fastener elements formed of synthetic resin, the fastener elements having stems that extend outwardly from the continuous, sheet-form material; and winding the material about the periphery of an inner member to reorient the stems to extend in multiple directions.

Implementations may include one or more of the following features. For example, the method includes extruding resin to form the inner member.

In some cases, the inner member is a rod.

In some embodiments, the inner member is electrically conductive.

The inner member of some embodiments is tubular. The tubular inner member can extend about an electrically conductive element.

In some cases, the method includes attaching the strip of material to the periphery of the inner member.

In some embodiments, the method includes heating and/or cooling the strip of material.

In some cases, winding the strip of material includes rotating the inner member.

Some embodiments further include providing the strip of material by molding a continuous, sheet-form material having rows of fastener elements formed of synthetic resin, the fastener elements having stems that extend outwardly from and integral with the continuous, sheet-form material and splitting the continuous sheet of material between adjacent rows of the molded stems to form the strip of material.

In another embodiment, the invention features a method of forming a fastener product and includes continuously introducing at least two streams of molten resin to a gap defined adjacent a periphery of a rotating mold roll, such that each stream of resin forms a respective strip-form base of a fastener filament at the periphery of the mold roll and fills select ones of cavities defined in the rotating mold roll to form fastener element stems extending integrally from the respective strip-form base; solidifying the resin streams and stripping the streams of resin from the periphery of the mold roll by pulling the solidified fastener element stems from their respective cavities to form at least two elongated fastener filaments.

Implementations of the foregoing aspects can include one or more of the following features. For example, the fastener elements have heads that are hook-shaped overhanging the base in one or more discrete directions. To form the hook-shaped heads, the cavities are hook-shaped. In a variation, the fastener elements have heads that are mushroom-shaped overhanging the base in multiple directions. To form the mushroom-shaped heads, the method includes deforming distal ends of the stems to form overhanging heads.

In some embodiments, methods include winding at least two fastener filaments to form a yarn having fastener elements extending in multiple directions.

In another aspect, the invention features a twisted fastener filament including an outer surface twisted about a common core and a series of fastener elements disposed about the core along its length; each fastener element comprising a stem integrally molded with the outer surface of the core with a distal head overhanging the outer surface.

In another aspect, the invention features a fastener product including a first twisted fastener filament including an outer surface twisted about a core and a series of stems disposed about the core along its length. The fastener product also includes a second twisted fastener filament wound about the first twisted fastener filament, the second twisted fastener filament including an outer surface twisted about a core and a series of stems disposed about the core along its length.

In another aspect, the invention features a fastener product including an inner member and a strip material wound about the periphery of the inner member. The strip material has rows of fastener elements formed of synthetic resin and the fastener elements include stems that extend outwardly from and integrally with a surface of the strip material.

Implementations of this aspect may include one or more of the following. For example, the inner member is a rod. The inner member is tubular. The inner member can be electrically conductive. The tubular inner member can have a conduit for extending about an electrically conductive member. The strip material is attached to the periphery of the inner member.

Implementations of any of the foregoing may include one or more of the following features. For example, the stems have heads that overhang the outer surface. The heads can be hook-shaped overhanging the outer surface in one or more discrete directions and/or the heads can be mushroom-shaped overhanging the outer surface in multiple directions.

Various aspects of the invention can provide a fastener filament, twisted or untwisted, that can be used in the production of various fastener products. The twisted fastener filaments and/or products having twisted and/or untwisted fastener filaments have multiple angles of engagement due to the reorientation of the fastener elements by, for example, winding and/or twisting of the fastener filaments. These multiple angles of engagement increase the probability for successful engagement with, for example, a loop product and/or nonwoven product.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

FIG. 1 illustrates a method and apparatus used to form a fastener product.

FIG. 1A is a top view of a laminate sheet being split.

FIG. 2 illustrates a method and apparatus used to form a fastener product.

FIG. 3 illustrates a cross-sectional, sectional view of a mold roll having sections of extended diameter.

FIG. 3A illustrates a cross-sectional, sectional view of a substrate having a splitting feature formed by the mold roll of FIG. 3.

FIG. 4 illustrates a method and apparatus used to form a fastener product.

FIG. 5 illustrates a method and apparatus used to form a fastener product with a backing material.

FIG. 5A illustrates a cross-sectional view of a fastener product along line AA of FIG. 5.

FIG. 5B illustrates a plan view of a fastener product formed by the method of FIG. 5.

FIG. 6 illustrates another method and apparatus used to form a fastener product.

FIG. 6A is a detail illustration of cut or chopped fastener filaments.

FIG. 6B is a plan view of a fastener product formed by the method illustrated by FIG. 6 along line B.

FIG. 6C is a detail illustration of cut or chopped twisted fastener filaments.

FIG. 7 illustrates a method and apparatus used to form a woven fastener product.

FIG. 7A illustrates a sectional plan of a woven fastener product.

FIG. 7B illustrates an alternative sectional plan view of a woven fastener product.

FIG. 8 illustrates a spooled fastener filament and method and apparatus for forming a twisted fastener filament.

FIG. 9A pictures a fastener product having multidirectional hooks.

FIG. 9B is a larger-scale picture of the product of FIG. 7A.

FIG. 10A pictures a fastener product having mushroom-shaped fasteners extending in multiple radial directions.

FIG. 10B is a larger-scale picture of the product of FIG. 8A.

FIG. 11 illustrates a method and apparatus for forming a fastener product.

FIG. 12 is a sectional view of a fastener product formed by the method of FIG. 11.

FIG. 12A is a side view of the product of FIG. 12.

FIG. 13 illustrates a side-view of a fastener product.

FIG. 13A illustrates a cross-sectional view of the fastener product of FIG. 9.

FIG. 14 illustrates woven fastener products.

FIG. 15 illustrates a fastener product applied to loop material.

FIG. 16 illustrates a fastener yarn.

Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

Referring to FIGs. 1-7, methods of producing fastener products are shown that build on the methods described by Fischer (U.S. Patent 4,794,028), which is incorporated herein by reference. Referring particularly to FIG. 1, the method employs a rotating mold roll 10 and a pressure roll 12 for molding a synthetic resin. The mold roll 10 and the pressure roll 12 provide a gap 14 into which the synthetic resin is directed by an extruder 16. An array of cavities 11 extends from the surface and substantially about the entire periphery of mold roll 10. Pressure in the gap 14 forces resin to enter and at least partially fill cavities 11, while excess resin forms a base substrate from which the fastener elements extend. The molded product may also be cooled on the mold roll until the solidified fastener elements are stripped from their fixed cavities by a stripper roll 13.

In some embodiments, cavities 11 of mold roll 10 have a head engaging portion to form, for example, discrete, spaced-apart hooks sized to engage a mating material. In these embodiments, the solidified product stripped from the mold roll has fastener elements capable of engagement. However, in other embodiments, the cavities may have only a stem forming portion (see FIG. 2). In these embodiments, the fastener product that is stripped from the mold roll has stems extending from the base that can be post-treated to form engaging heads.

Referring still to FIG. 1, after the sheet-form array of fastener elements 18 is formed and removed from the mold roll, the sheet is split in the machine direction between individual columns of fastener elements 18 by a splitting device 20, such as an ultrasonic cutter or a rotational or stationary blade, for example, (see FIG. 1A) forming a series of elongated fastener filaments 22, each having only one column of fastener elements. Although FIG. 1A shows only two columns of hooks, tapes with, for example, tens or hundreds of columns of hooks can be molded and split. In some cases, each cut filament has two or more columns of elements. Because fastener filaments 22 are formed in the machine direction, the filaments 22 can be fed to an adjacent station in a continuous process. Each elongated fastener filament 22 is twisted by a twisting device 24 into elongated twisted fastener filaments 26. Prior to twisting, the elongated

fastener filaments 22 may be heated to soften the plastic, then, subsequent to twisting, cooled to allow the twisted form to set into a continuous column having an array of fastener elements 18 extending radially in multiple directions, to form hook fasteners with multiple planes of engagement. Alternatively, the fastener filaments can first be twisted, then heated and subsequently cooled. The twisted fastener filaments 26 are then transferred directly to a storage roll 28 from which the filaments 26 may be dispensed at a later time.

Referring to FIG. 2, an alternative embodiment is illustrated including a topping roll 30. Synthetic resin is directed into a gap 14 and then formed into a sheet-form array of stems 34 projecting from a base. The stems 34 are reheated by heater 38, thus softening the plastic to allow for subsequent forming of a fastener element. The heated stems 34 are then shaped by topping roll 30, which applies pressure to distal ends of the fastener elements 34 thus forming the fastener elements 35 with heads that overhang the base. As described above, the sheet of fastener elements 35 may then be split between columns of fastener elements 35 into elongated fastener filaments 37. The fastener filaments can then be twisted into a final shape and/or diverted to a storage roll, as examples. The stem ends may be heated in a non-contacting process, such as by flame or hot wire, or in a contacting process, such as by heating roll 30. A suitable non-contacting process is provided in U.S. 6,248,276, the entire contents of which are hereby incorporated by reference.

To facilitate splitting of the sheet-form molded substrate, a separation groove can be molded into the substrate. Referring to FIG. 3, mold roll 200 has splitting rings 202 having a region of increased diameter shaped to create the separation grooves T (FIG. 3A). Groove T is an integral, relatively thin, rupturable joint that permits easy separation of filaments. Roll 200 has two sections 204 adjacent each ring 202 that define mold cavities 206 shaped to form stems 34. Other splitting features include embedded yarns, perforations, or the like.

Referring now to FIG. 4, an alternative to splitting the resin sheet between rows of stems is to extrude individual, relatively narrow columns 208 of heated resin and to deliver those columns of resin to gap 14. As in the methods described by FIGS. 1 and 2, resin from each of the columns enters select ones of the cavities 11, forming molded stems, while excess resin from each column forms a base from which the molded stems extend. Exiting the gap 14 are individual strands of filaments having integrally molded stems extending from the base that can be cooled on the mold roll and then removed.

Referring now to FIG. 5, the twisted fastener filament 26 is added to a surface of a substrate 40. Referring also to FIG. 5A, following heating and/or twisting of the filament, the twisted fastener filament 26 is placed on substrate 40 along the machine direction of the substrate 40, with the fastener elements 34 extending radially from a central axis of each filament. The twisted fastener filament 26 placement on the substrate can trace a repeating pattern, such as longitudinally extending lines, curves, waves, etc., and/or the placement can be random (see FIG. 5B). The twisted fastener filament 26 may be bonded to the substrate 40 by heating the filament 26 and/or by adhering the filament 26 to a surface of the substrate 40, or the fastener elements 18 of the fastener filaments 26 may be attached to loops and/or fibers extending from a surface of the substrate 40. It should be noted that the untwisted fastener filaments may also be attached and/or bonded to substrate 40.

FIG. 6 illustrates another embodiment where untwisted fastener filaments 42 are being formed by passing synthetic resin between a mold roll 10 and a pressure roll 12 and then splitting a molded sheet-form array of fastener elements 18 with a splitting device 20 forming fastener filaments 22, as described above. The fastener filaments are then cut or chopped into pieces 50, each piece 50 having fastener elements 18 extending from a base 44 (see FIG. 6A), by a chopping device 46 and then applied randomly to a substrate 48. The chopped pieces 50 are cut to a predetermined length, each piece preferably having at least one fastener element extending from a base of piece 50. The dimensions of the untwisted pieces can be selected to cause a significant portion of the pieces to fall with their fastener elements extending upward or at varying engagement angles. The pieces may be randomly distributed in orientation (see FIG. 6B). As a variation, the filaments, twisted or untwisted, may be cut into discrete lengths and applied to the substrate in a predetermined pattern or arrangement (not shown). For example, the filaments can be cut and then applied to the substrate in the cross-machine direction in a spaced-apart arrangement. In some cases, the pieces 50 are cut so as to each have several fastener elements. The filament pieces 50 may be bonded to the substrate 48 by thermal bonding, applying adhesive and/or other similar techniques. Alternatively, the fastener elements 18 of the fastener filament pieces 50 may be attached to loops and/or fibers extending from a surface of the substrate 48. In some cases, the filaments are twisted before being cut into pieces 50 and applied to the substrate 48, to increase the randomness of the angles of engagement (see FIG. 6C).

In yet another embodiment, a twisted or untwisted fastener filament may be cut into discrete lengths of fastener filament strands as described above with reference to FIG. 6 and these discrete pieces of fastener filament strands may be formed into a nonwoven web material by forming methods as are known in the art for example by wet laying and dry laying processes. Exemplary nonwoven forming methods include air laying, carding, and wet laying. Briefly, in an air forming or air-laying process fibers having typical lengths ranging from about 3 to about 50 millimeters (mm) or longer are separated and entrained in an air supply or air stream and then deposited onto a forming screen or other foraminous forming surface, usually with the assistance of a vacuum supply, in order to form a dry-laid fiber web. Equipment for producing air-laid webs includes the Rando-Weber airformer machine available from Rando Corporation of New York and the Dan-Web rotary screen air former machine available from Dan-Web Forming of Risskov, Denmark. Carding processes are known to those skilled in the art and are further described, for example, in U.S. Pat. No. 4,488,928 to Alikhan and Schmidt, and involve starting with staple-length fibers in a batt that is combed or otherwise treated to provide a web of generally uniform basis weight. Wet laying processes as are known in the art involve suspending fibers in a liquid slurry, depositing the slurry on a screen or other foraminous forming surface and then removing the excess liquid.

The nonwoven web material may desirably further comprise other filaments or fibers such as thermoplastic staple fibers and/or cellulosic fibers. Staple fibers are well known in the art and may be monocomponent or multicomponent fibers, and may be crimped or uncrimped. Cellulosic fibers include those comprising at least 50 percent by weight cellulose or a cellulose derivative, and may include cotton, fibers from woody stalks, such as jute, flax, kenaf, and cannabis, typical wood pulps and derivatives, non-woody cellulosic fibers, cellulose acetate, cellulose triacetate, rayon, milkweed, or bacterial cellulose. After the discrete fastener filament strands and/or other fibers have been formed into a nonwoven web material, the web may be bonded by methods as are known in the art such as by thermal point bonding, ultrasonic bonding, adhesive bonding, through air bonding, and entanglement bonding including mechanical needling and hydroentangling.

Nonwoven web materials and laminates of nonwoven webs with other webs or film materials find a wide variety of use in disposable and durable goods such as personal care garments and protective garments. Examples of personal care products include, but are not

limited to, infant, child and adult personal care products such as diapers, training pants, swimwear, incontinence garments and pads, sanitary napkins, wipes and the like, and protective garments include, but are not limitaed to medical and health care products such as bandages, surgical drapes, gowns, headwear and footwear, examination gowns, and protective workwear garments such as coveralls and lab coats.

Referring to FIGs. 7 and 7A, a device for forming a fastener product is shown having parallel workstations 60 and 62 and a weaving device 64. Subsequent to forming the sheet-form array of fastener elements 18 and splitting the sheet into at least two elongated fastener filaments 22, each of the elongated fastener filaments 68 are sent to parallel workstations 60 and 62 for further processing. Parallel workstations 60 and 62 both comprise twisting machines 70. The fastener filaments 22 are twisted by the twisting machines 70 (twisting may include heating the fastener filaments as described above), then the twisted fastener filaments 26 are each directed to a weaving device 64, which weaves fastener filaments into a woven fastener material 74. The woven fastener material 74 may then be directed to a storage roll, for example, for storage. Untwisted fastener filaments 22 can also be woven by omitting the twisting operation (see FIG. 7B).

It should be noted that each parallel workstation 60 and 62 may comprise a different operation. For example, workstation 60 may comprise a twisting machine and a storage roll and workstation 62 may comprise a chopping machine, a substrate roll, and a storage roll. Additionally, more than two parallel workstations may be utilized having workstations comprising various processes. For example, the sheet-form array of fastener elements may be split into a number of elongated fastener filaments and each of the fastener filaments may be directed to a different parallel workstation.

As an alternative to weaving, the weaving device can be replaced by a winding device (not shown) to wind at least two twisted or untwisted or a combination of twisted and untwisted fastener filaments together to form a yarn 130 having fastener elements extending outwardly in multiple radial directions (see FIG. 16). The filaments can be heated or unheated prior to winding. If heated, the yarn can be cooled to set the wound form. The yarn can then be further processed. For example, the yarn can be woven, cut, chopped, deposited on a substrate, or the like, as examples.

FIG. 8 shows a storage roll 80 having a roll of an untwisted fastener filament 22. At least a portion of the fastener filament 22 is removed from the roll 80 and then heated by heater 85. The heated fastener filament 82 is directed to a twisting device 86 where the filament 82 is twisted into the twisted filament 26. The twisted filament 26 may then be sent to a workstation for further processing or directed directly to a storage roll, for example.

FIGs. 9A-10B are images of twisted fastener filaments formed by methods similar to those illustrated in FIGs. 1 and 2. Referring first to FIGs. 9A and 9B, a fastener filament 90 is shown having a twisted outer surface and a plurality of fastener elements 92 extending radially in multiple directions from the surface of the fastener product 90. Fastener elements 92 comprise hooks 94 with heads 96 extending in various directions to create a twisted fastener product having a plurality of fastening angles.

Similarly, referring to FIGs. 10A and 10B, a fastener filament 100 is shown having fastener elements 102 extending radially in multiple directions from a surface of the fastener product 100. Fastener elements 102 have mushroom-shaped heads 104 that overhang the twisted surface of the fastener product 100, also creating a twisted fastener filament having a plurality of fastening angles.

Referring to FIG. 11, another method for forming a fastener product 110 having multiple angles of engagement is shown. A formed fastener filament 37 is directed to a rod 111 formed of extruded material, such as resin. The rod of resin is rotated while it advances such that as the fastener filament is brought into contact with the rod 110, it is wrapped about the peripheral surface of the rod in a continuous process of wrapping and advancing. The rod can also be a discrete length. Also, the filament 37 can cycle about the rod while the rod advances and/or rotates or is stationary. The filament can similarly advance. To affix the filament 37 to the surface of the rod, the rod can be heated to heat bond the filament to the surface. Other methods of attaching the filament can also be used such as adhesives, mechanical fasteners, or the like.

The rod can be of any cross-sectional shape and can be formed of any material including polymers, metals, foams, etc. The rod can also be electrically conductive. Where the rod is electrically conductive, the rod or conductive wire can be electrically isolated by an insulator prior to wrapping the fastener filament about the wire. Similarly, the filament 37 can be wrapped about tubular members 112 of any cross-sectional shape to form a fastener product having a conduit 114 extending therethrough (see FIGs. 12 and 12A).

Referring now to FIGs. 13 and 13A, an illustration of a section of a twisted fastener filament 26 is shown. Fastener filament 26 includes fastener elements 18 extending from a twisted surface 114. Referring particularly to FIG. 13A, fastener filament 26 has a core 116 with a twisted outer surface 114.

FIGs. 14-15 illustrate various fastener product embodiments. FIG. 14 shows a woven fastener product 74 comprising woven, twisted fastener filaments 26. The woven fastener product 74 has fastener elements 18 extending in multiple directions from the surface of each twisted fastener filament 26. While woven fastener product 74 consists of only twisted fastener filaments 26, it should be noted that woven product 74 can be comprised of twisted or untwisted fastener filaments and/or non-fastener filaments such as string, yarn, or other fibers, for example.

Referring now to FIG. 15, a fastener product is shown having a twisted fastener filament 26 with hooks 18 extending in multiple radial directions from a twisted outer surface of the filament 26 and a substrate 40 comprising loop material 138 sized to engage hooks 18. Because hooks 18 extend in multiple radial directions from the twisted surface of fastener filament 26, some hooks 18 do not engage loops 138 of substrate 40. Unengaged hooks 18 are available to engage a different substrate containing, for example, loops, woven fibers, and/or non-woven fibers. Unengaged hooks 18 may also engage loops 138 of substrate 40 thereby forming a self-engageable fastener product. Hooks 18 may also be sized to engage substrate 40, or a like material, to a greater extent relative to a second material (not shown). This aspect reduces the probability of unintentional removal of the filaments 26 from the substrate 40. While FIG. 15 shows substrate 40 comprising loops, substrate 40 can also be a non-woven, woven fibers, or any other engageable material.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, the fastener elements may be J-shaped, T-shaped, palm trees, multi-facing, flat heads, mushrooms, etc. Additionally, as an alternative to cooling the heated fastener filament to set the reoriented fastener elements and/or stems, the twisted and/or wound filaments can be attached or bonded to, for example, a substrate. This attaching or bonding can be by for example, staking, melt bonding, adhereing, etc., end portions of the filament to the substrate. Accordingly, other embodiments are within the scope of the following claims.